Decadal Prediction of North Atlantic and North Pacific Variability

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EC-Earth (Earth System Model) and NEMO (state of the art framework for oceanographic research) are the major dynamical models implemented, maintained and used by the CFU.

In order to run these models, the CFU has computational resources available at the following High Performance Computing (HPC) machines

- Ithaca (IC3): EC-Earth (v2.2, v2.3, v3.0, v3.1) and NEMO (v2, v3.2, v3.3) deployed; basic platform, periodic allocation. V2.3: IFS/NEMO: T159L60/1° at Eq.
- MareNostrum (BSC): EC-Earth (v2.1, v2.2, v2.3) and NEMO (v2, v3.2, v3.3) deployed; during the last 24 months the CFU has used ~2.5 million CPU hours on MareNostrum, all of them from competitive resources.
- ECMWF: EC-Earth (v2.1, v2.2, v2.3); 2.0 million SBU (standard billing units) have been used as part of a Special Project.
- Lindgren (PDC): EC-Earth (v3.1), 3.5 million CPU hours via PRACE. V2.3: IFS/NEMO: T799L800/0.25° at Eq.

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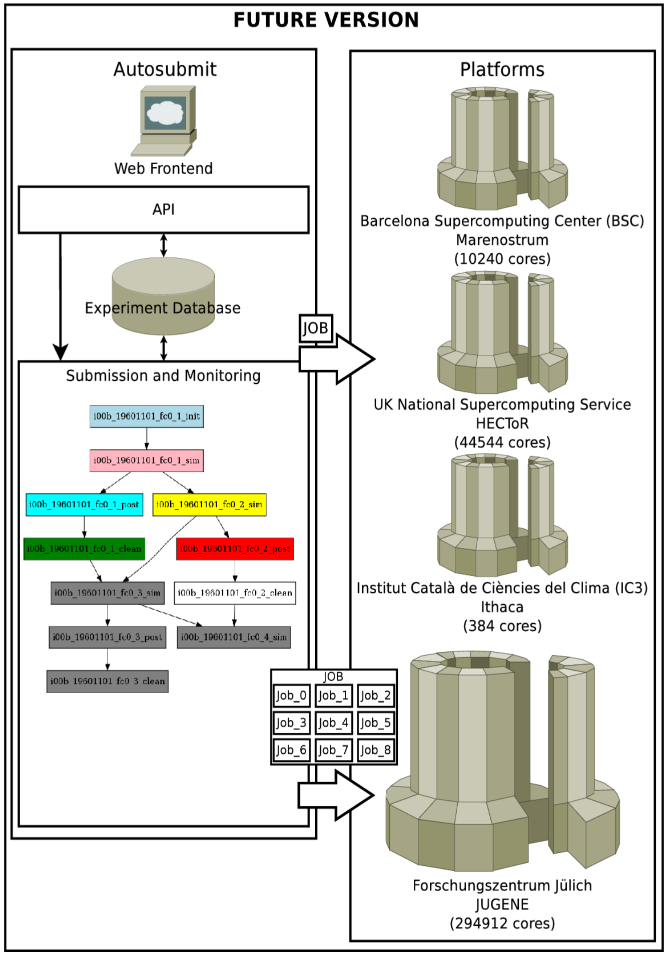
A typical climate forecast experiment executes thousands of jobs, a task that can obviously not be done manually. Autosubmit acts as a wrapper for a HPC. The experiment is defined as a sequence of jobs that it submits and manages. The job list is constantly monitored so that when a job is complete, the next one can be executed. A database allows for adequate documentation of the experiments.

- Divided in 3 phases: ExpID assign, experiment creation, run.
- Separation between experiment and autosubmit code.
- Configuration files for autosubmit and experiment.
- Database to store small experiments information.
- Common code templates for all platforms.
- Templates for different types of experiments.
- Script for recovery after crashes and failures.
- Tackling the different schedulers: a) create a base class HPCQueue, b) Implementation of specific classes (MnQueue, ItQueue)



Each job is represented in the monitoring tool with a colour depending of the status: green=completed, orange=running, blue=pending, etc.

Initialization of coupled decadal climate prediction systems

Climate Forecasting Unit (CFU)

at Institut Català de Ciències del Clima (IC3), Barcelona, Spain

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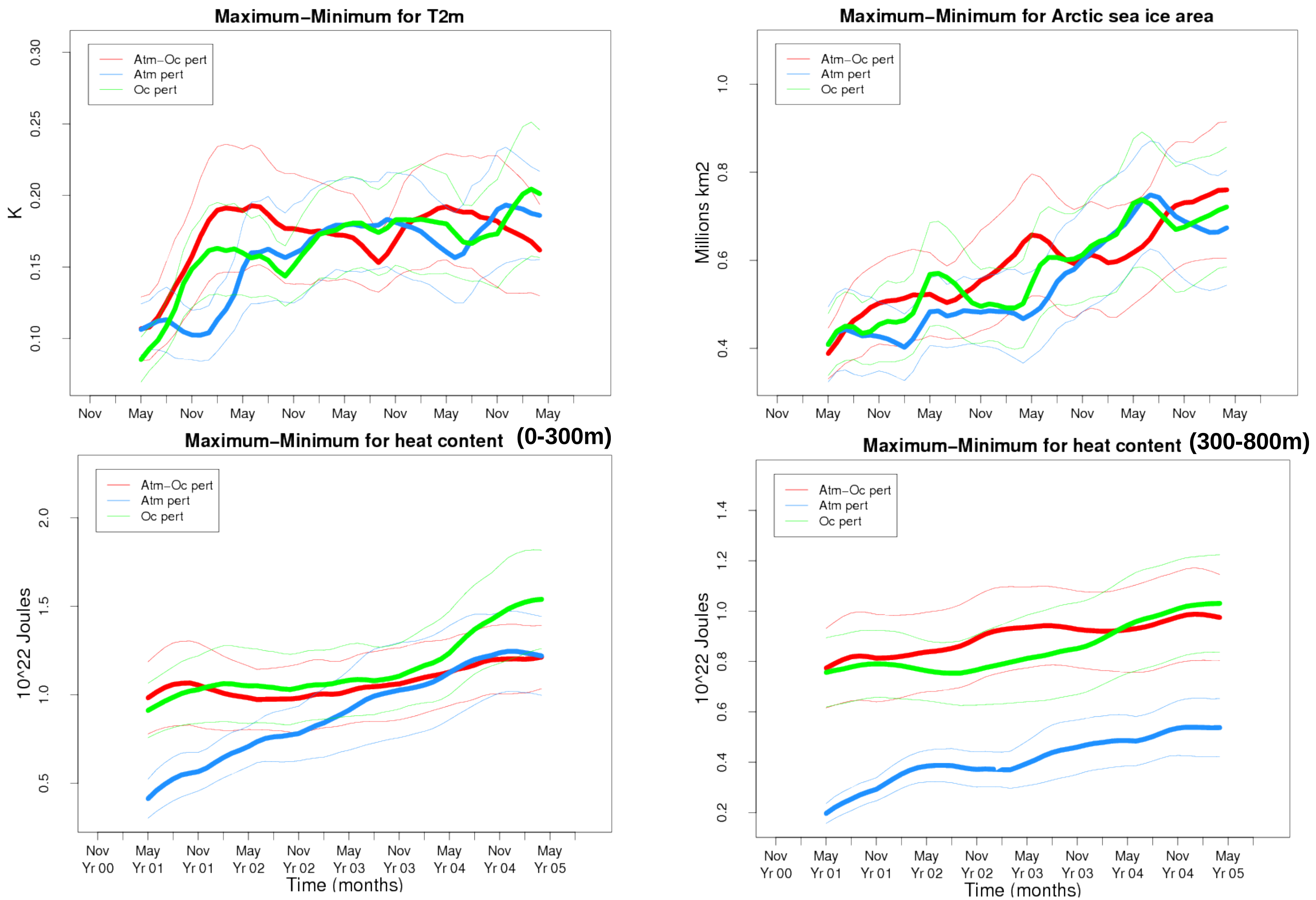
Spread (mean range maximum-minimum) for five-year long experiments (start dates every five years over 1960-2005) with ocean (green), atmosphere (blue) and ocean-atmosphere (red) initial perturbations.



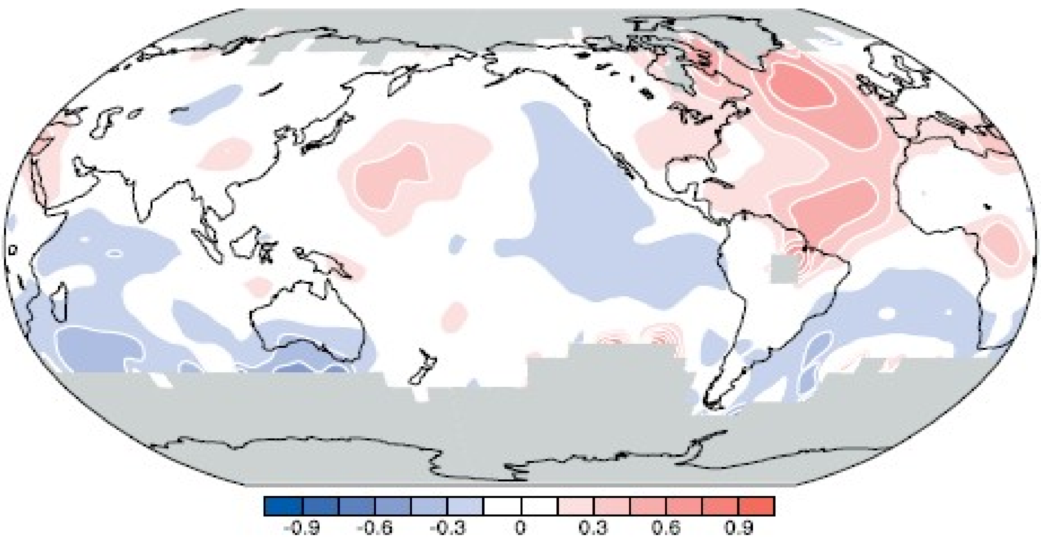
EC-Earth

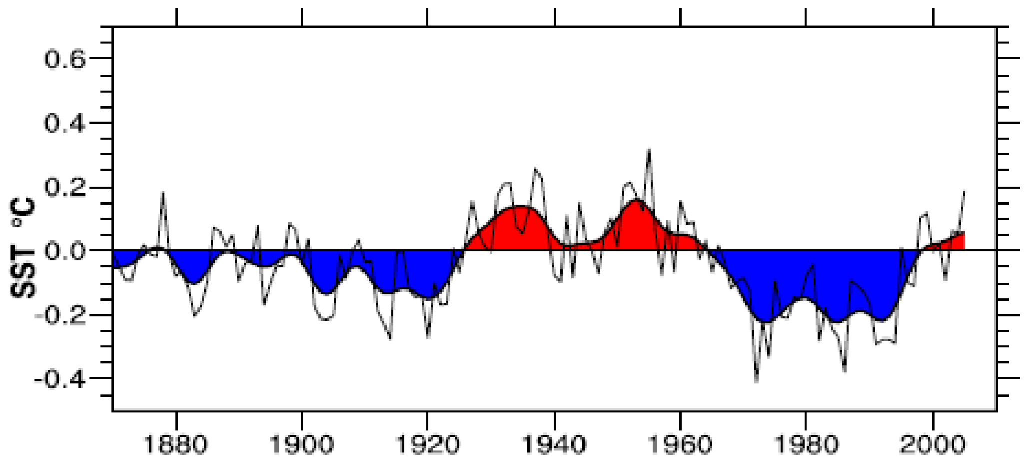
Decadal prediction of North Atlantic variability

Climate Forecasting Unit (CFU)

at Institut Català de Ciències del Clima (IC3), Barcelona, Spain

Atlantic Multi-decadal Oscillation (AMO)





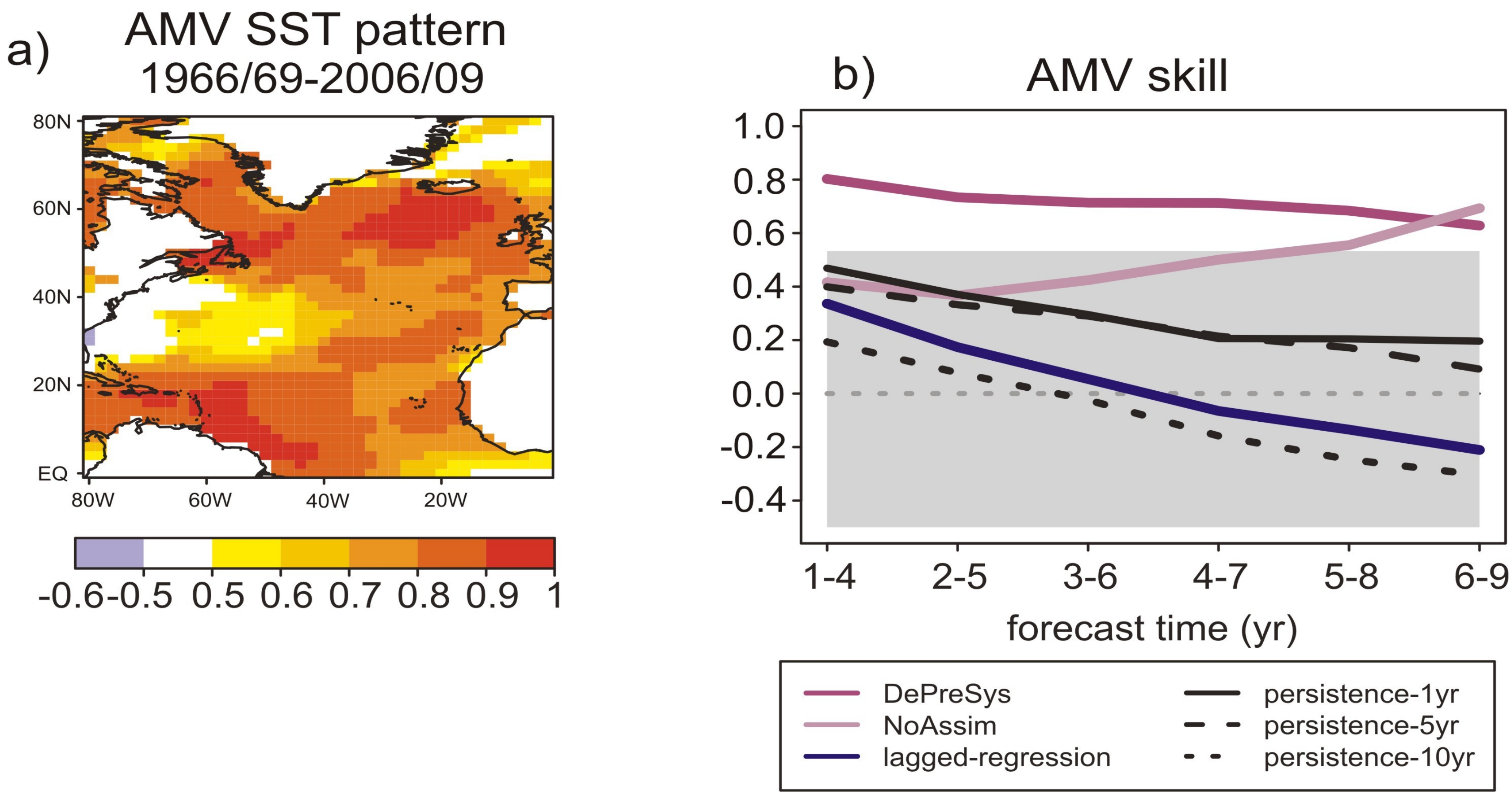
SST anomalies in the North Atlantic [EQ-60N/80W-0E] minus global SST anomalies [60S-60N]

Trenberth and Shea (2006, GRL)

Due to the limited length in the observational record, a more proper denomination for the AMO-like variability is Atlantic Multi-decadal Variability (AMV)

(i.e. Ting et al. 2011, GRL)

(a) Correlation map of annual ERSST anomalies onto the AMV index. (b) Prediction skill for the AMV index of DePreSys (purple), NoAssim (pink), lagged-regression model (blue), and one- (black solid), five- (black dash) and ten-year persistence models.



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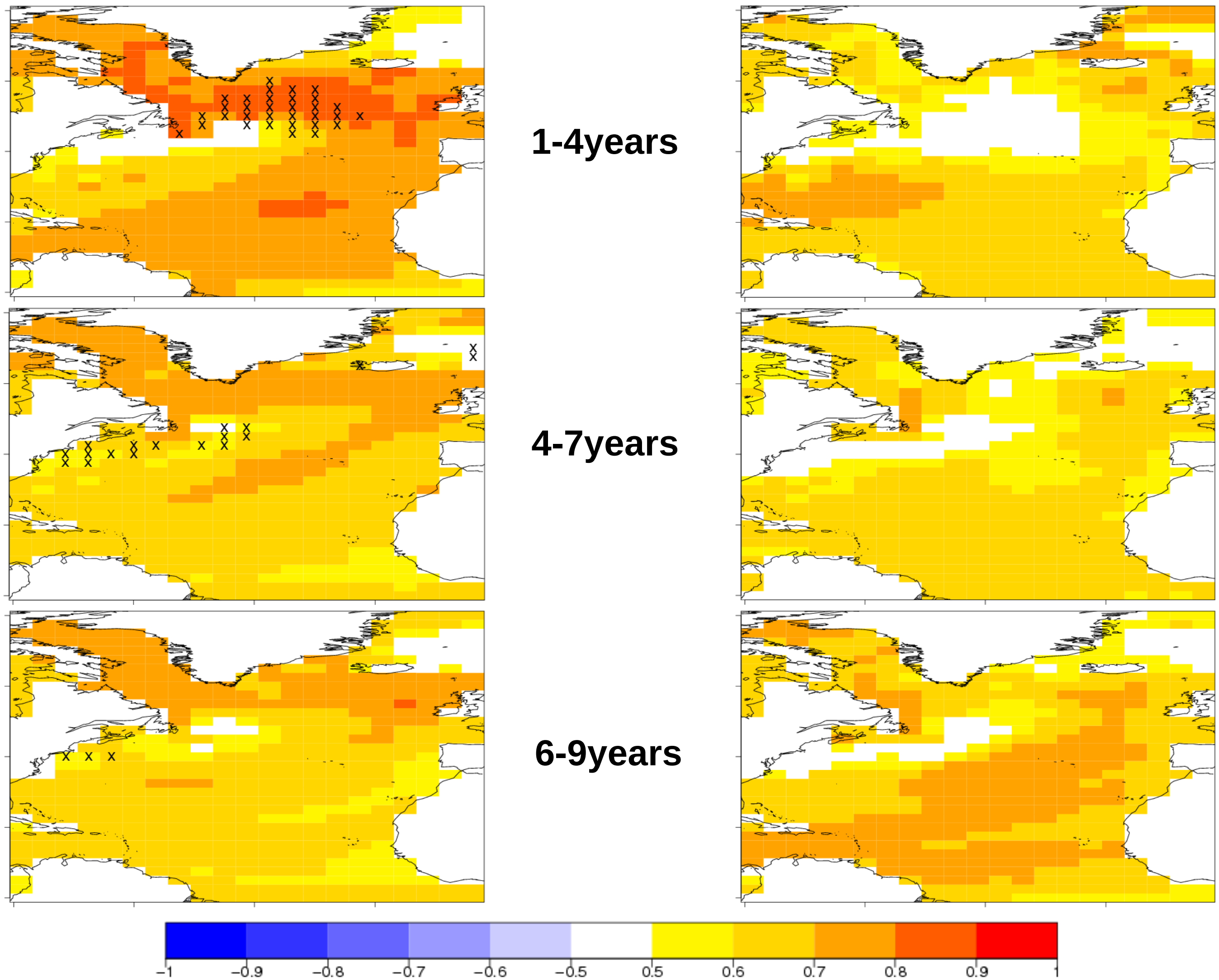
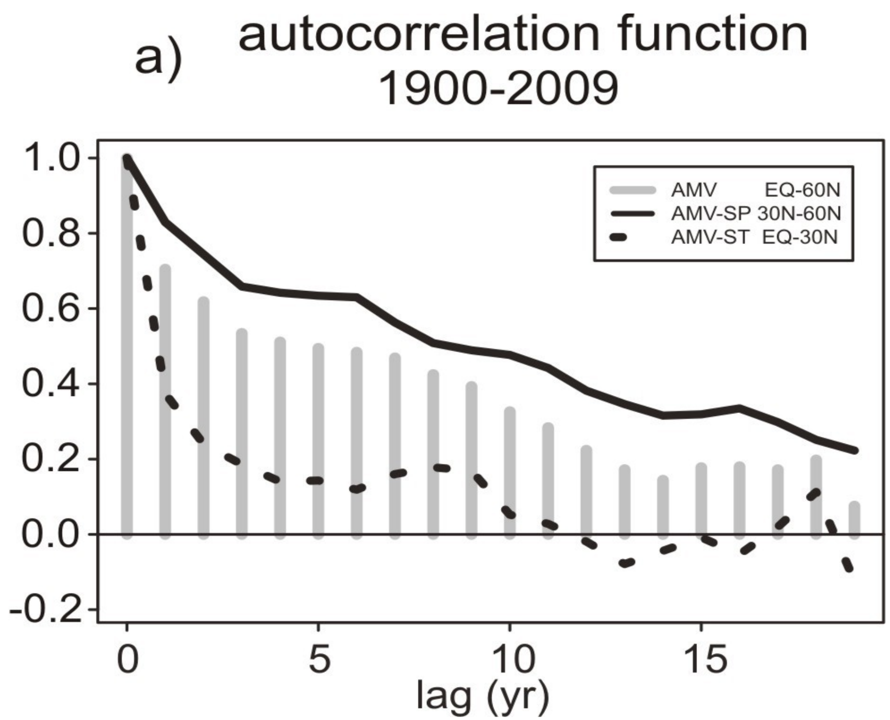
Correlation-based skill maps of ensemble-mean SST anomalies onto the observed AMV index (ERSST); 4-year forecast average

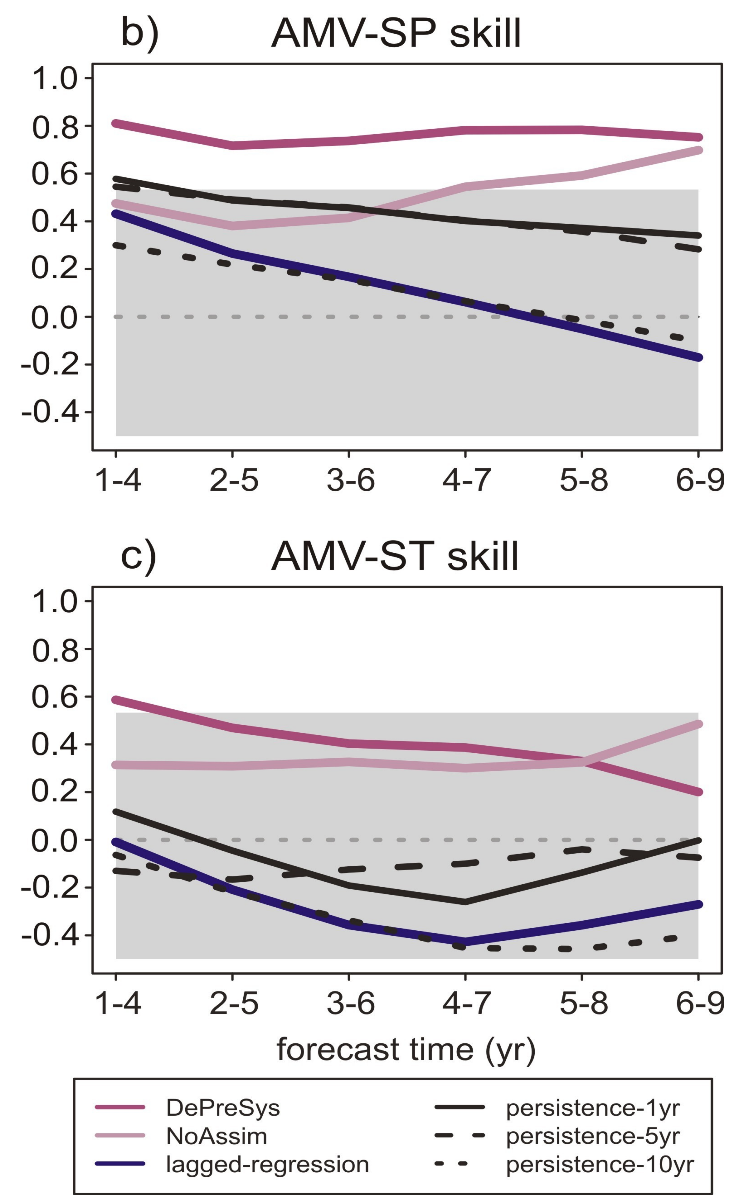
DePreSys

NoAssim



(a) Autocorrelation function of the AMV (grey bars), subpolar branch (AMV-SP) and subtropical branch (AMV-ST) indices for ERSST in 1900-2009 (training + verification periods). (b,c) Prediction skill for the AMV-SP and AMV-ST indices.





Decadal prediction of North Pacific variability

Climate Forecasting Unit (CFU)

at Institut Català de Ciències del Clima (IC3), Barcelona, Spain

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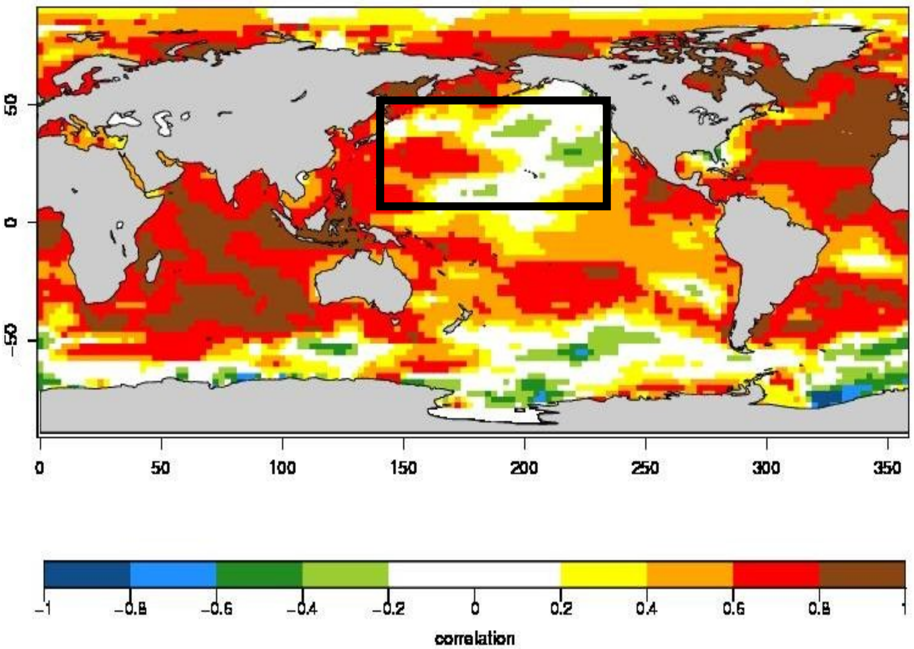
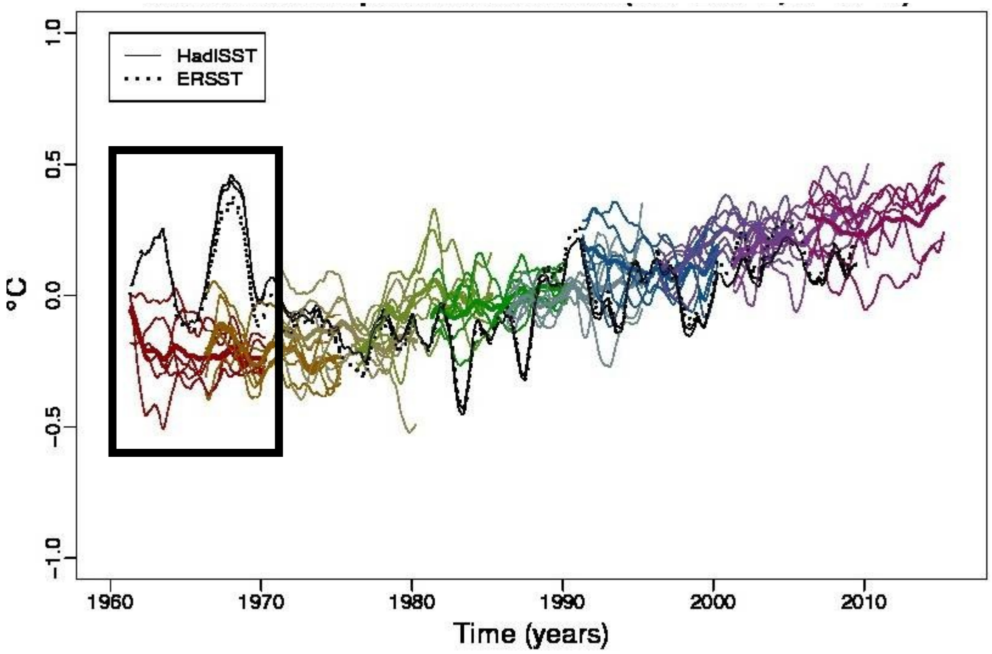
Identifying the causes for the low decadal climate forecast skill over the north Pacific

SST correlation skill 2-5 years



SST anomalies (155-235°E, 10-45°N)



Multi-model = ENSEMBLES + DePreSys + Ec-Earth contribution to CMIP5

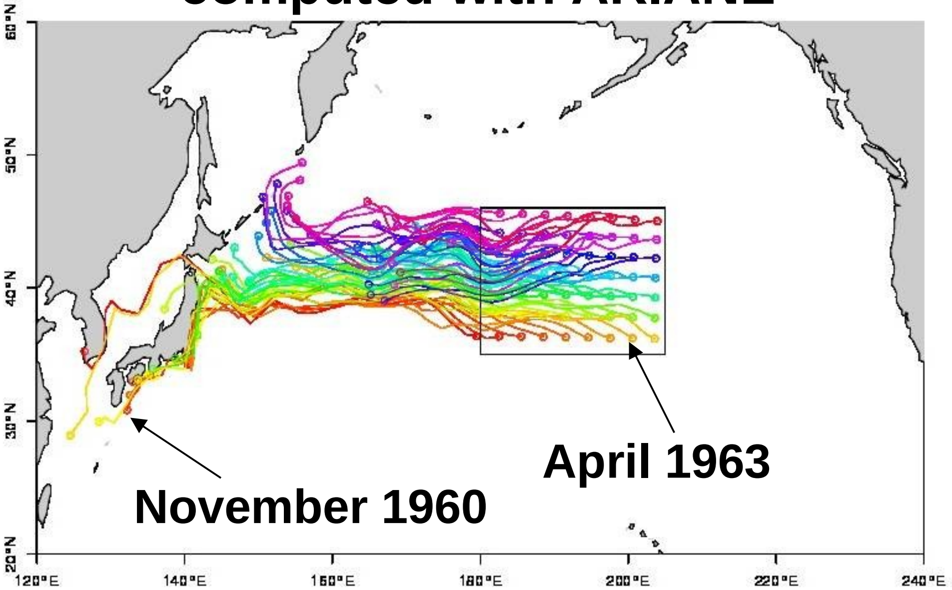
North Pacific = region of lowest skill worldwide because 1963 and 1968 warming events are missed

V.Guemas, F.Lienert, F.Doblas-Reyes., H.Du, Y.Soufflet

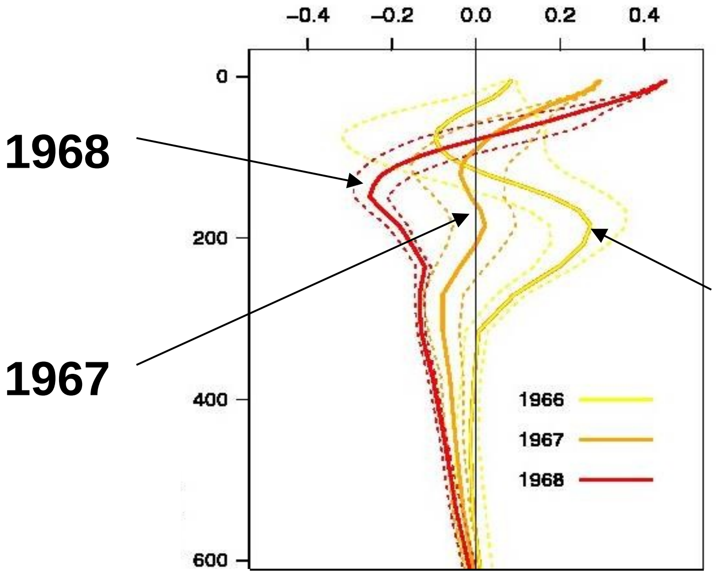
Climate Forecasting Unit

Identifying the causes for the low decadal climate forecast skill over the north Pacific

NEMOVAR backward trajectories computed with ARIANE



NEMOVAR temperature anomaly profile (170-235°E – 10-45°N)



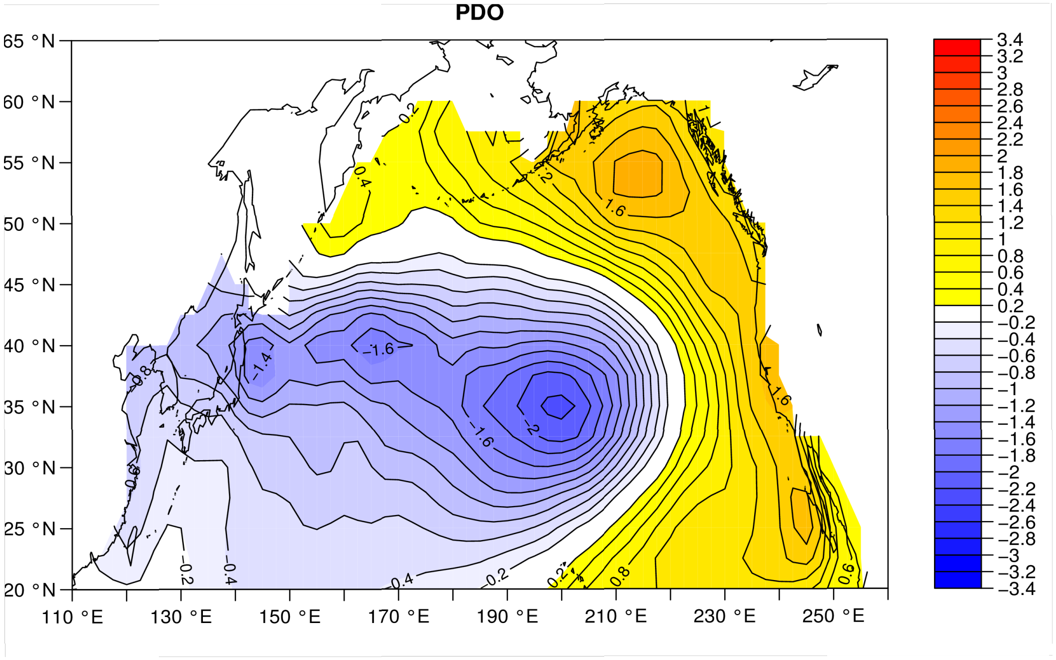
1963 warming : warm ocean heat content anomaly travelling along the Kuroshio-Oyashio, trapped in a thinner and thinner mixed layer

1968 warming : deep anomaly brought toward surface by mixing processes

V.Guemas, F.Lienert, F.Doblas-Reyes., H.Du, Y.Soufflet

Decadal Prediction of the Pacific Decadal Oscillation

DePreSys Assim/NoAssim re-forecasts started each November 1960-2005



Definition of the PDO: leading EOF mode of North Pacific (north of 20ºN) SST anomalies

Explains 34% of total variance of annual-means in ERSSTv3b

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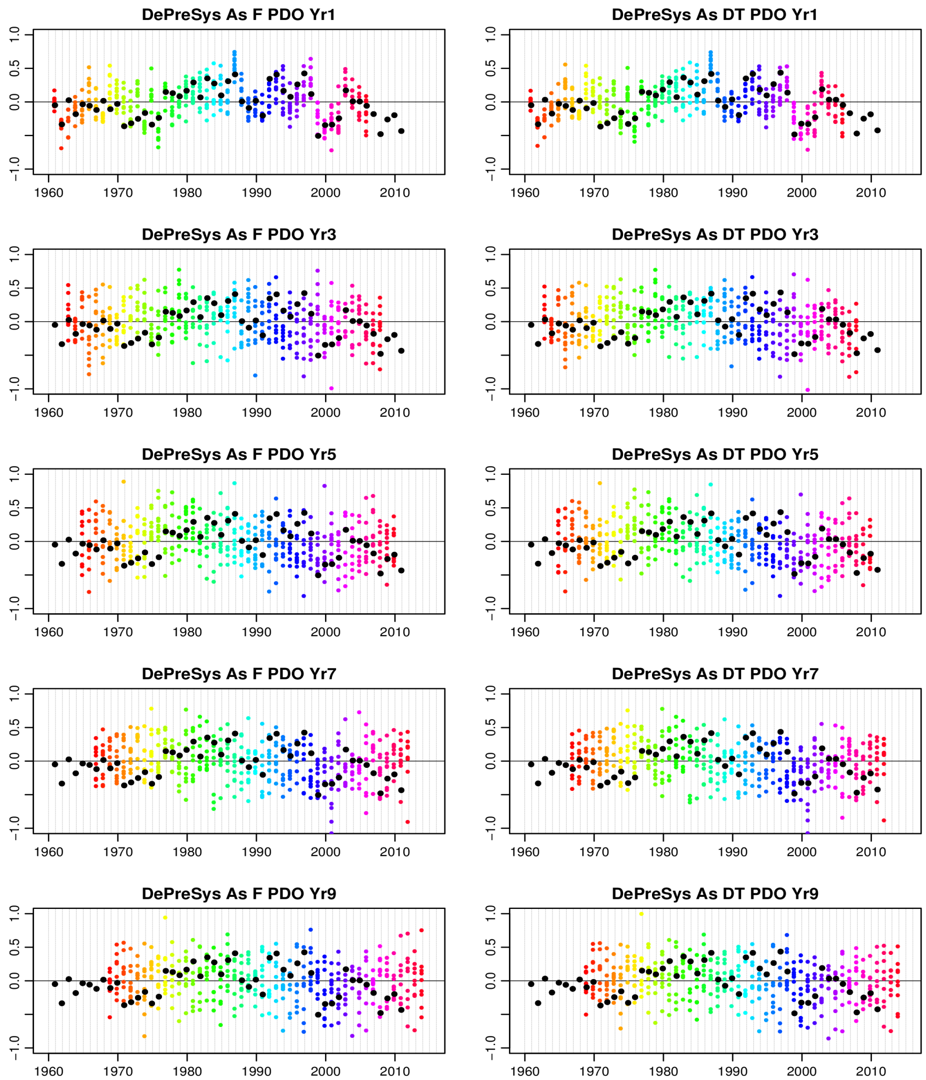
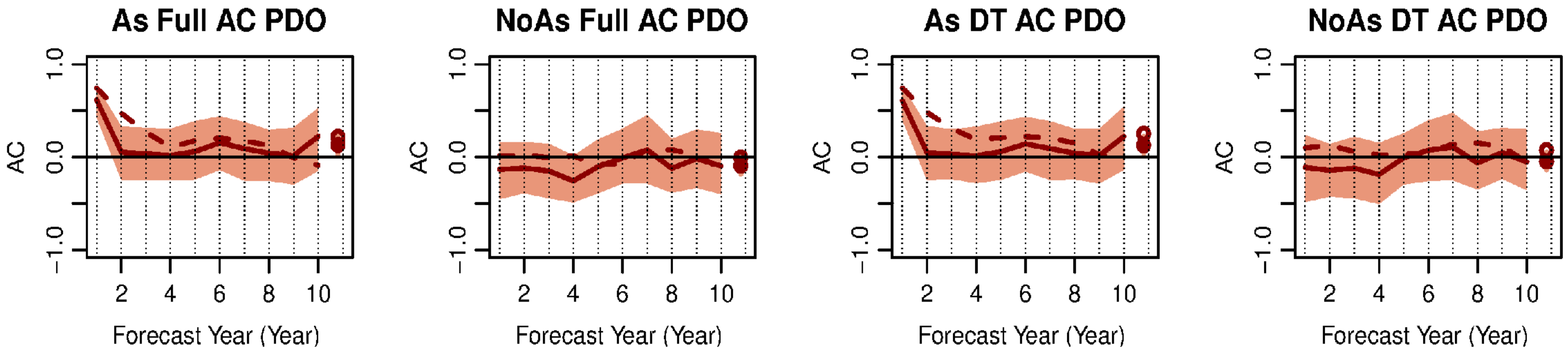
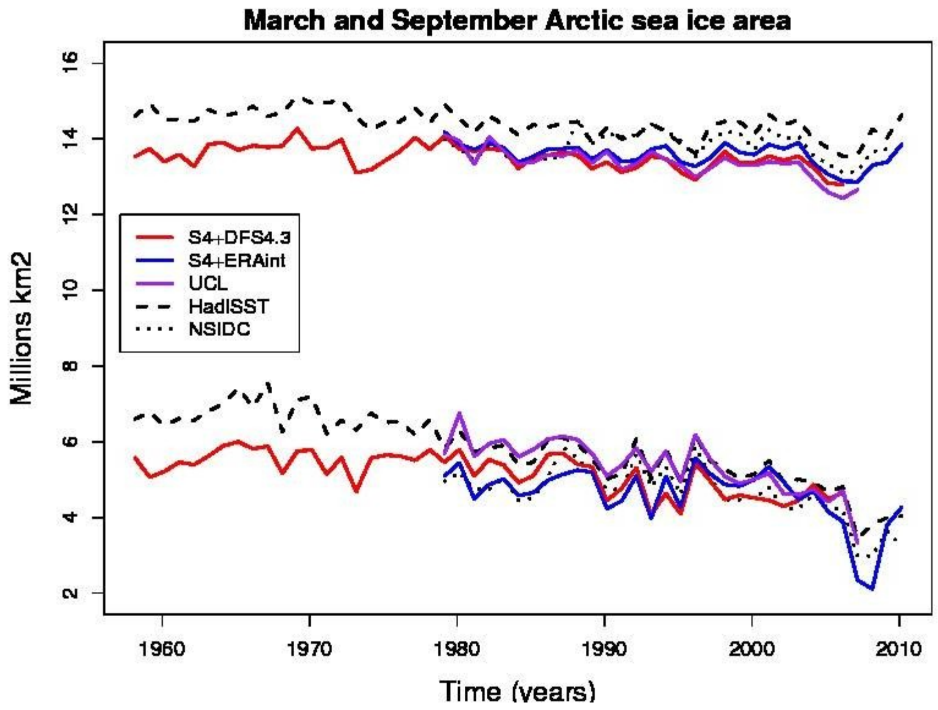
Decadal prediction of the Pacific decadal oscillation (PDO) from DePreSys_PP (left) and the detrended data (right). The PDO is estimated as projections on the ERSST leading EOF in the North Pacific. Each start date is drawn with a different colour.



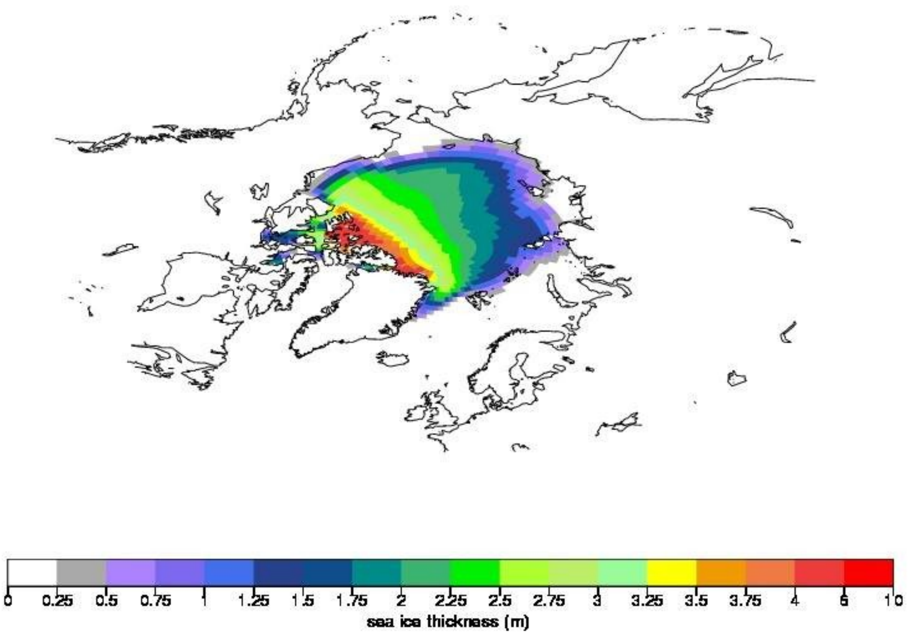
Skill of the decadal predictions of the Pacific decadal oscillation (PDO) from DePreSys_PP Assim and NoAssim (left) and the corresponding detrended data (right). The PDO is estimated as projections on the ERSST leading EOF in the North Pacific. Bootstrap confidence intervals are drawn in pink. Dashed lines correspond to estimates of perfect predictability. Dots at the end of each panel show the average skill along the forecast time.



Generation of sea ice initial conditions for seasonal to decadal climate predictions



September sea ice thickness (m)



- 1958-2006 and 1979-2010 * 5-member strongly constrained sea ice historical simulation
- NEMO3.2/LIM2 forced DFS4.3/ERAinterim + wind perturbations (ENSEMBLES method)
- Nudged toward NEMOVAR-S4 5 members

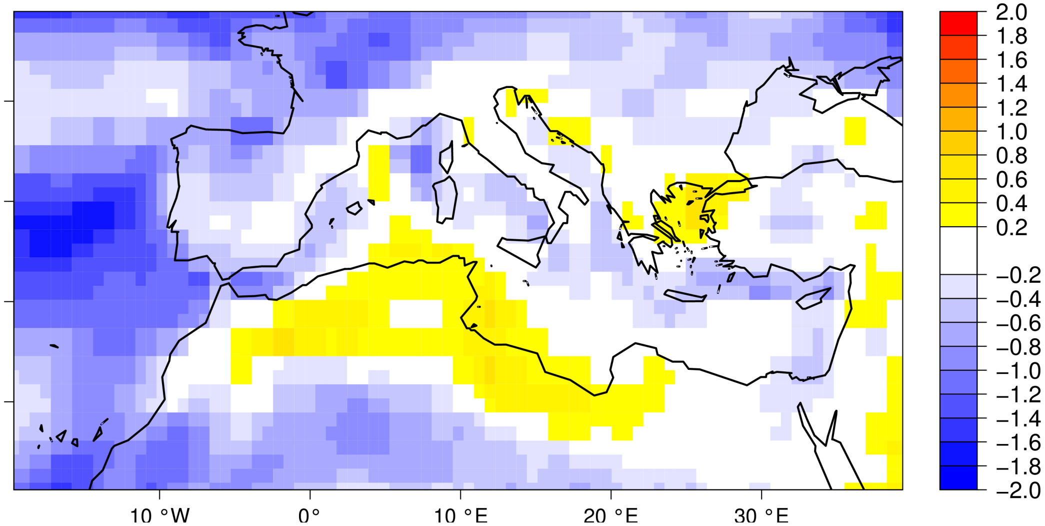
➡ **ORCA1 monthly restarts on request : vguemas@ic3.cat, f.doblas-reyes@ic3.cat**

Investigating usefulness of seasonal to decadal climate forecasts for the renewable energy sector in the Mediterrean region – the CLIMRUN project

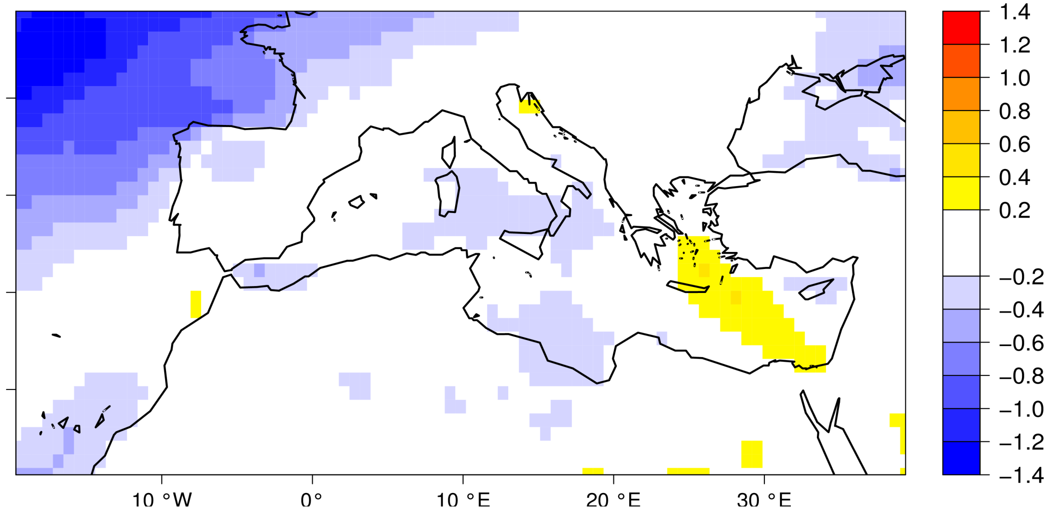
Climate Forecasting Unit (CFU)

at Institut Català de Ciències del Clima (IC3), Barcelona, Spain

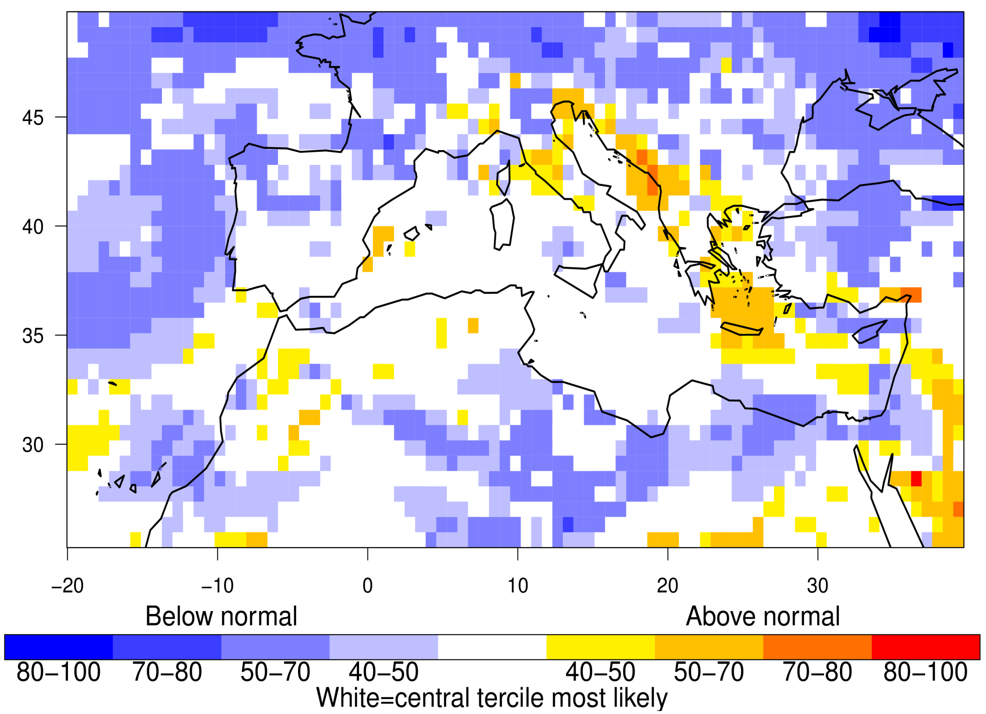
Observed 10m wind speed (m/s) DJF 2010/2011



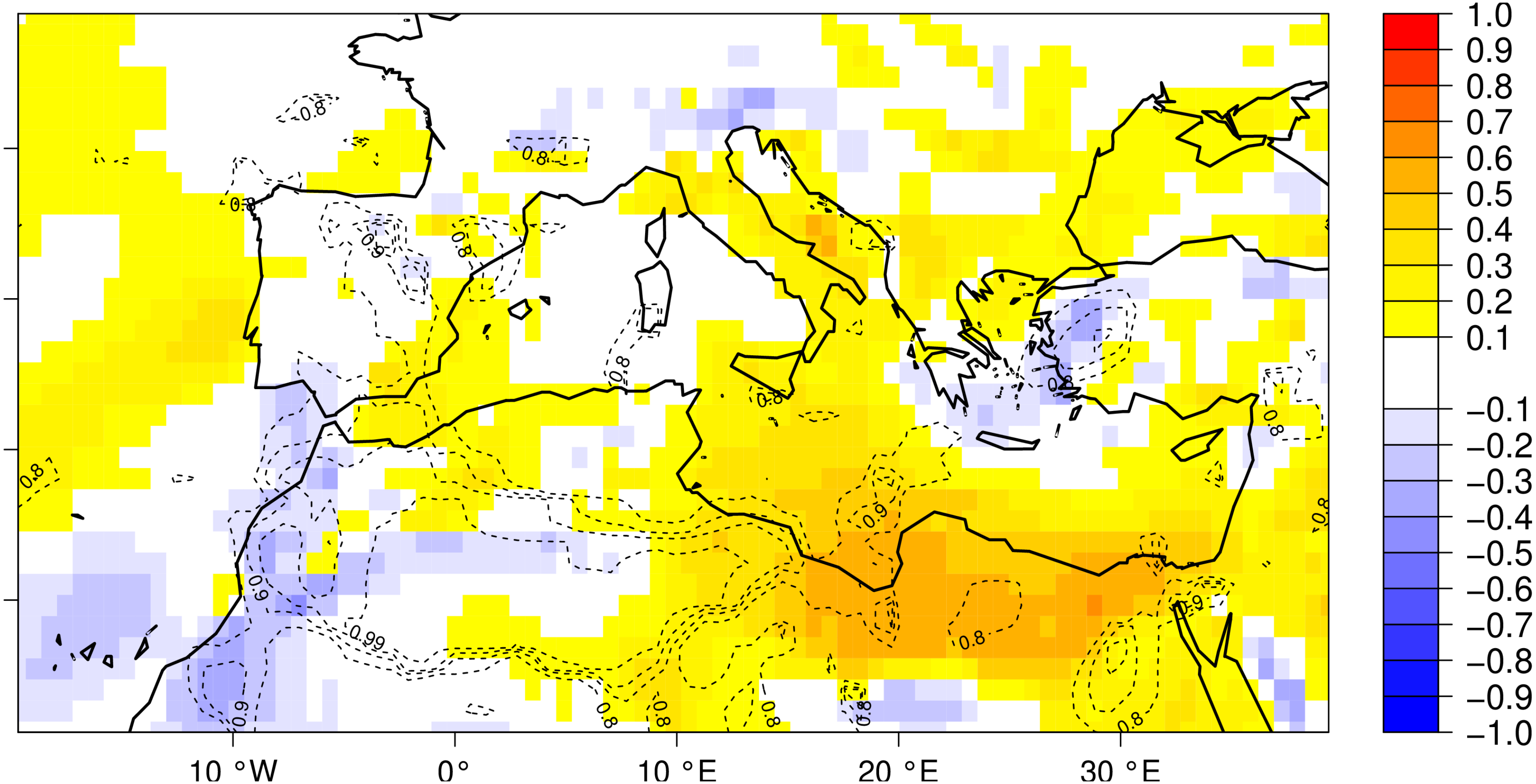
Forecast 10m wind speed (m/s) DJF 2010/2011



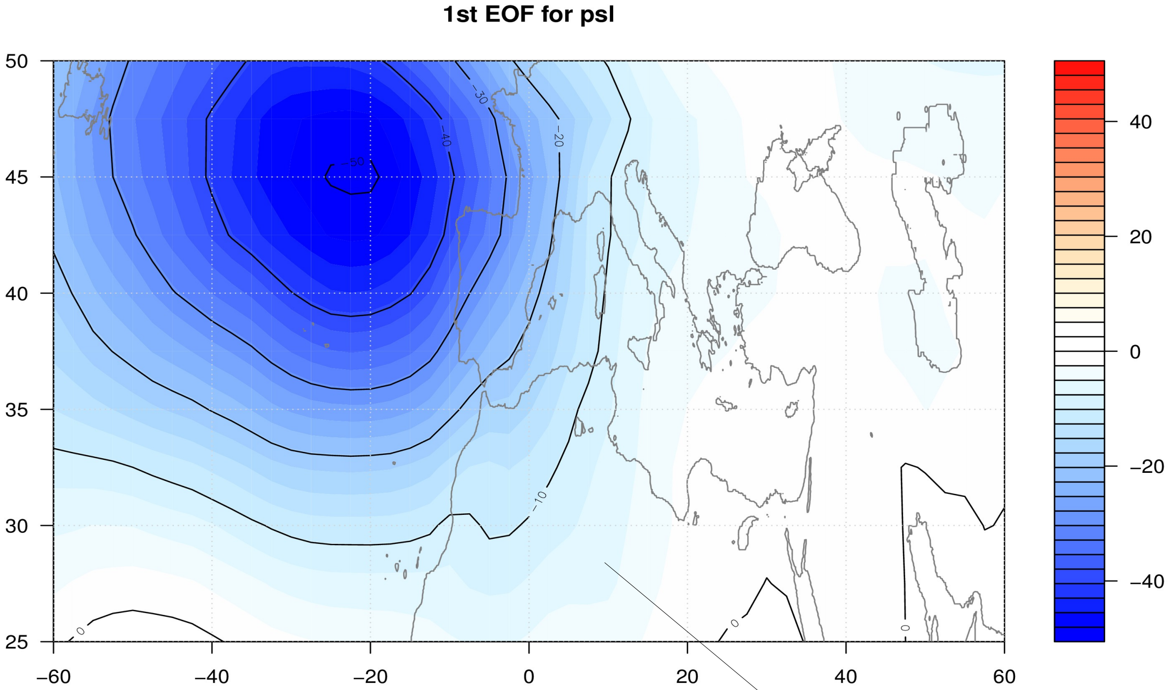
Probability most likely tercile (%) DJF 2010/2011



Seasonal predictions of 10-metre wind speed from ECMWF System 4 for the Nov 2010 start date, with the climatology computed from 1981-2010. Reference from ERA Interim.



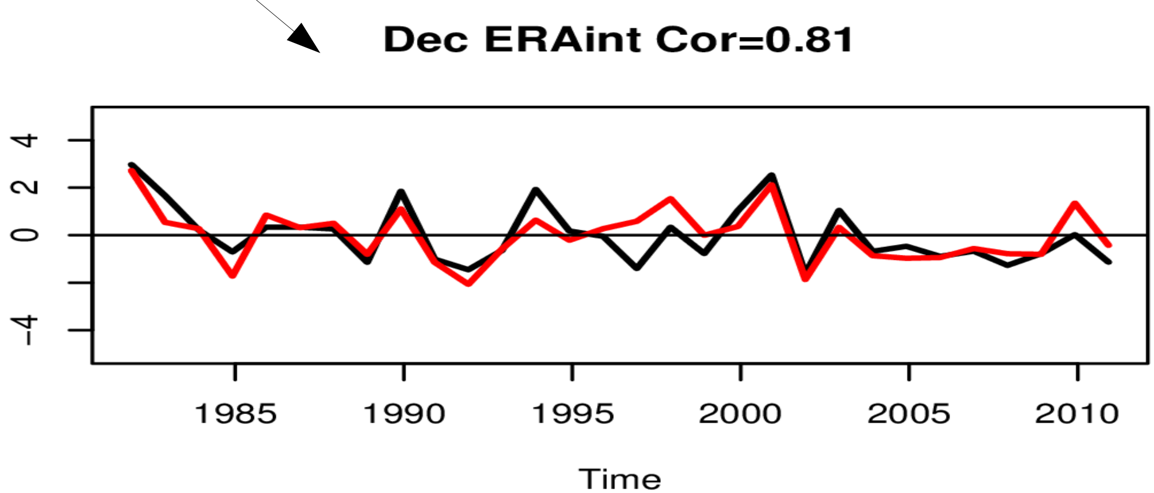
Ensemble mean correlation of one-month lead DJF 10-metre wind speed from ECMWF System 4 computed from hindcasts over 1981-2010. Reference from ERA Interim.

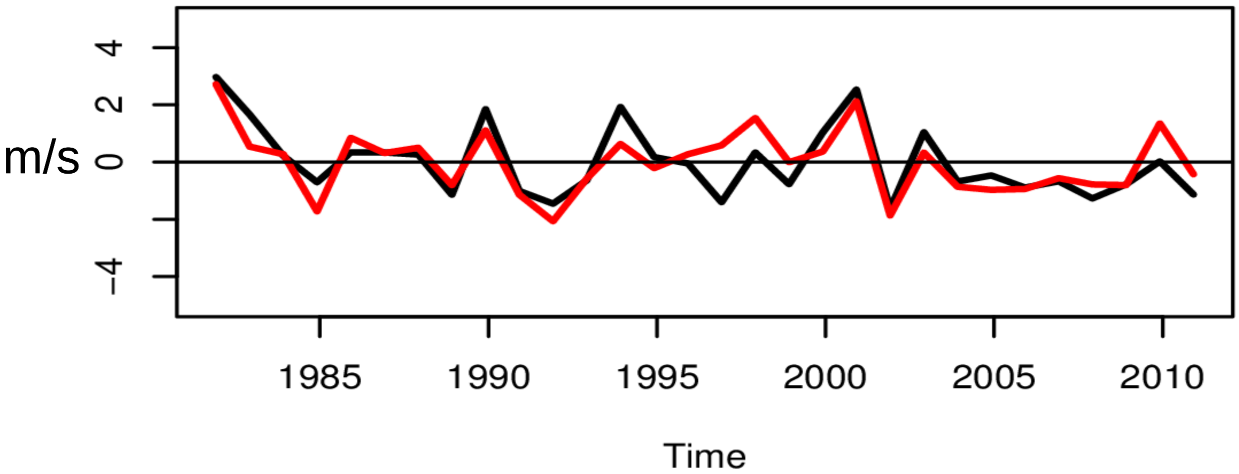


Downscaled 10-metre wind speed anomaly using information on large-scale atmospheric circulation

Leading 4 EOFs of sea level pressure in December

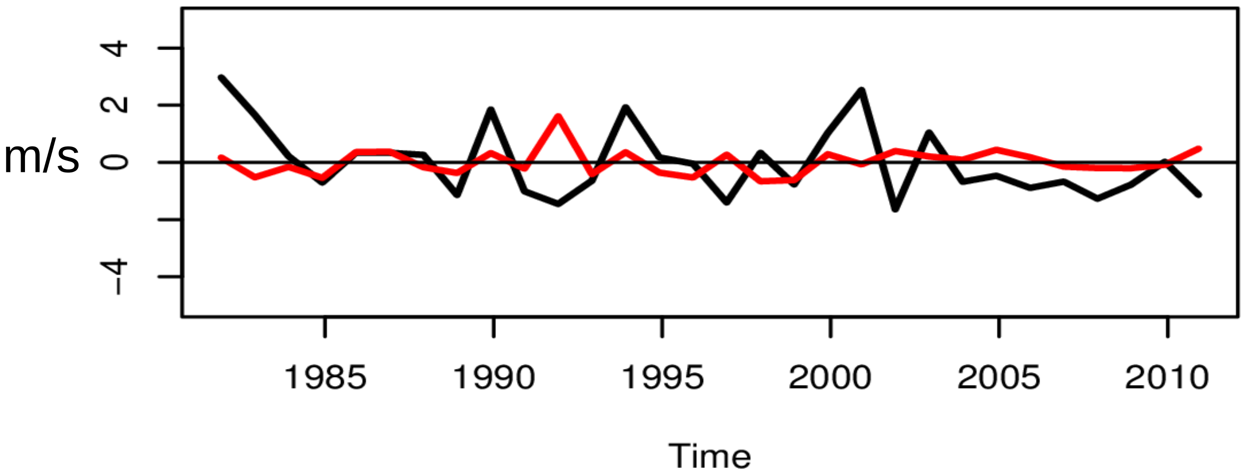
to estimate monthly wind speed at wind farm location in north-west Spain
(red, downscaled estimate; black, observation)





Predictor ERAinterim Dec SLP

cor=0.8



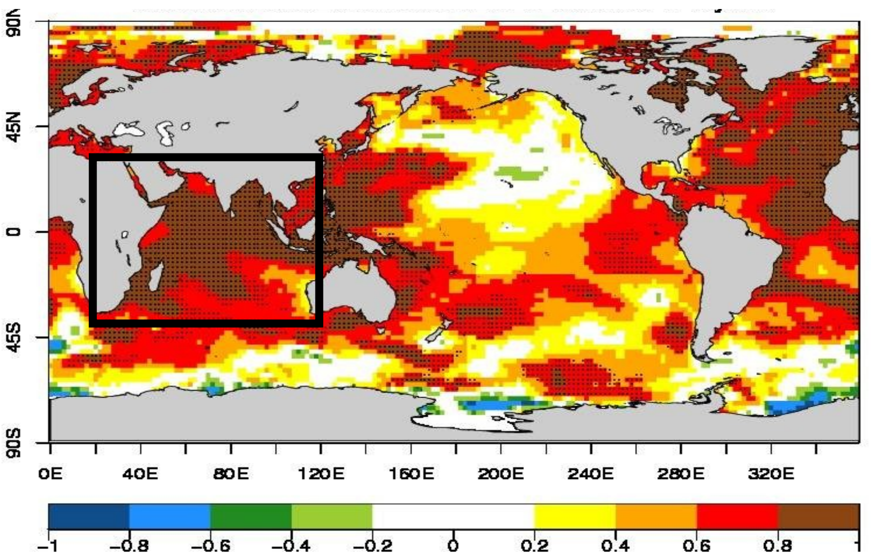
Predictor ECMWF S4 Dec SLP
Nov started forecasts

cor=0

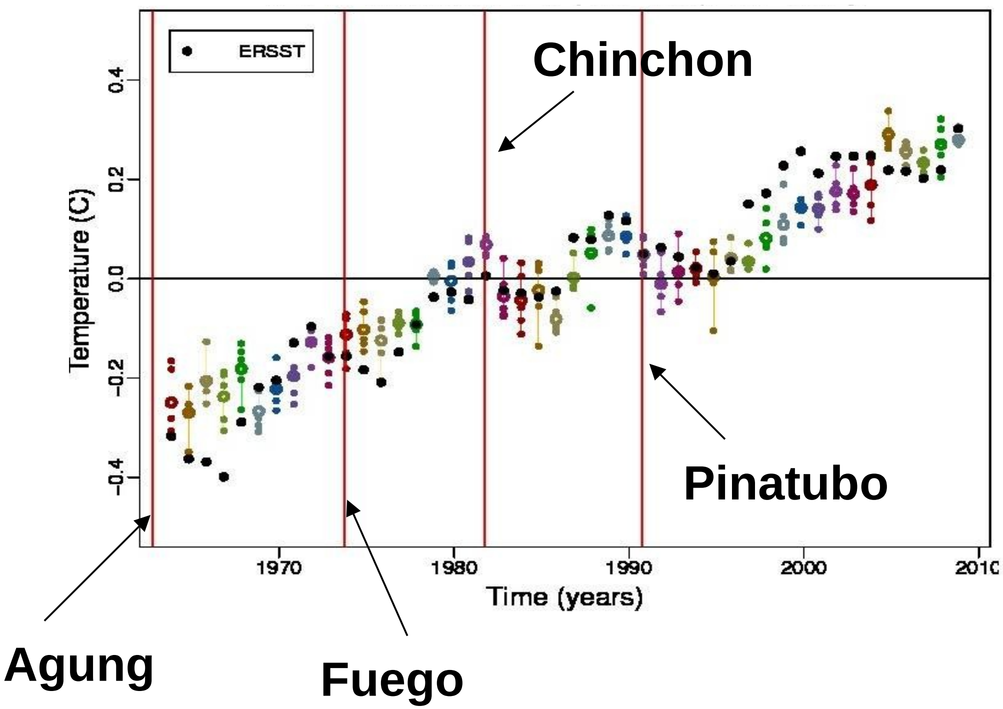
Downscaled 10-metre wind speed anomaly using information on large-scale atmospheric circulation (leading 4 EOFs of Dec sea level pressure anomalies) to estimate monthly wind speed at wind farm location in north-west Spain
(red, downscaled estimate; black, observation)

The Indian Ocean: the region of highest skill worldwide in decadal climate prediction

CMIP5 SST correlation skill 2-5 years



SST anomalies (20-120°E, 40°S-30°N)



Indian Ocean = region of highest skill worldwide mainly thanks to the global warming trend and the volcanic aerosols

V.Guemas, S.Corti, J.Garcia-Serrano, F.Doblas-Reyes., M.Balmaseda, L.Magnusson

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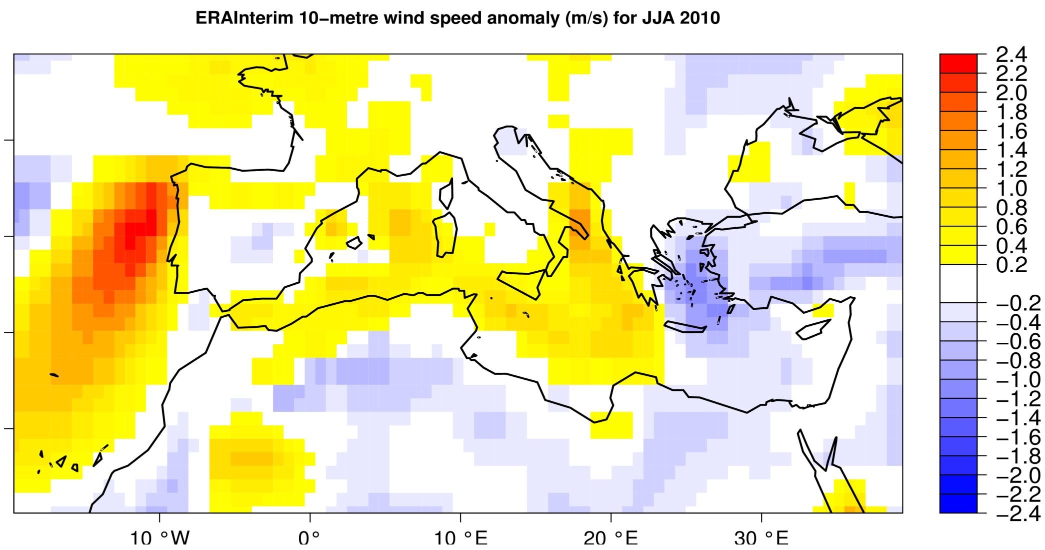
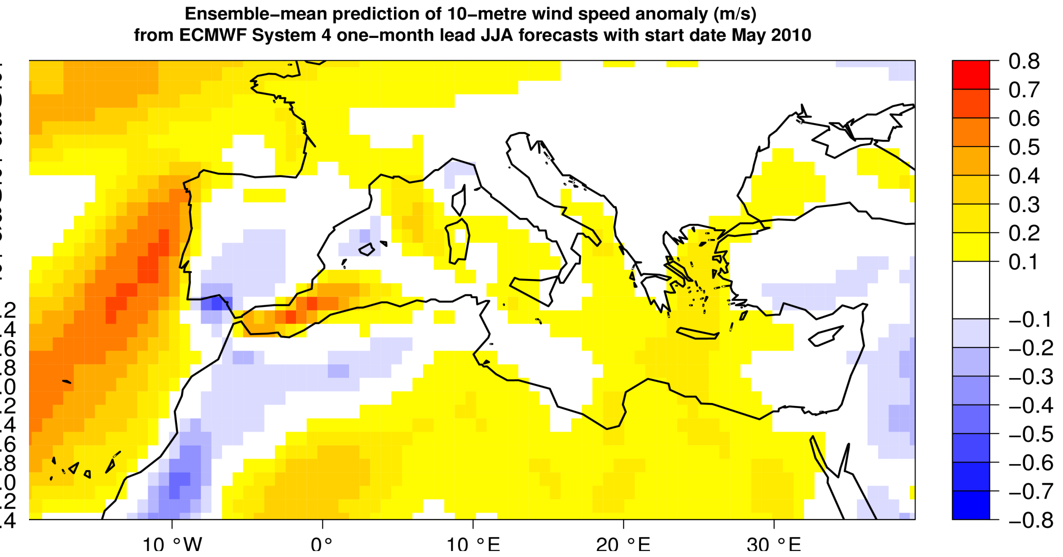
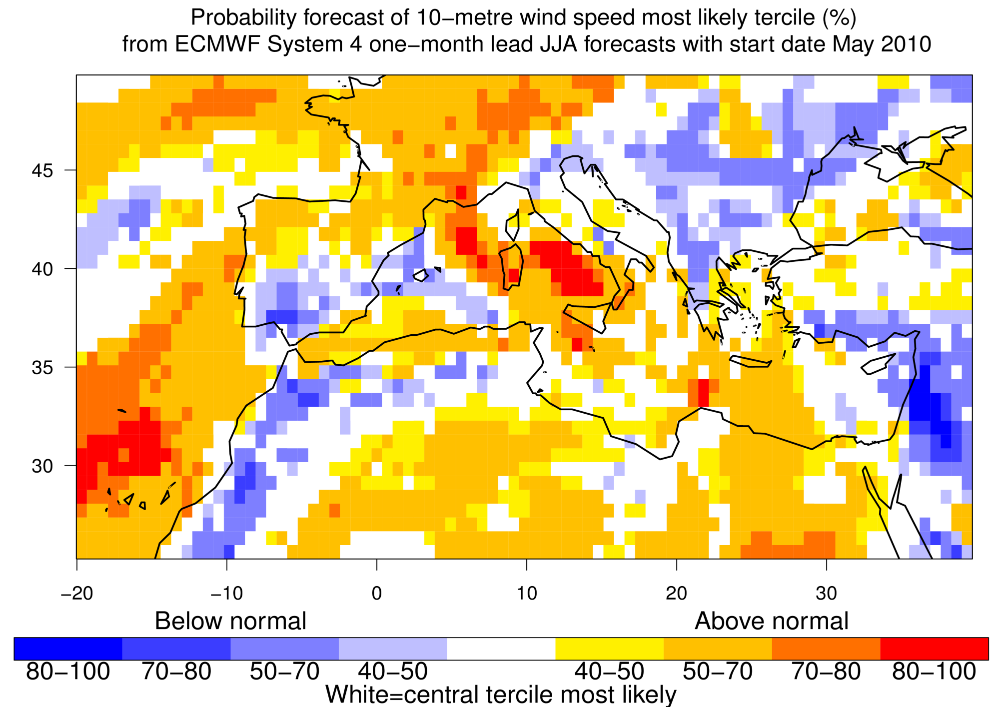
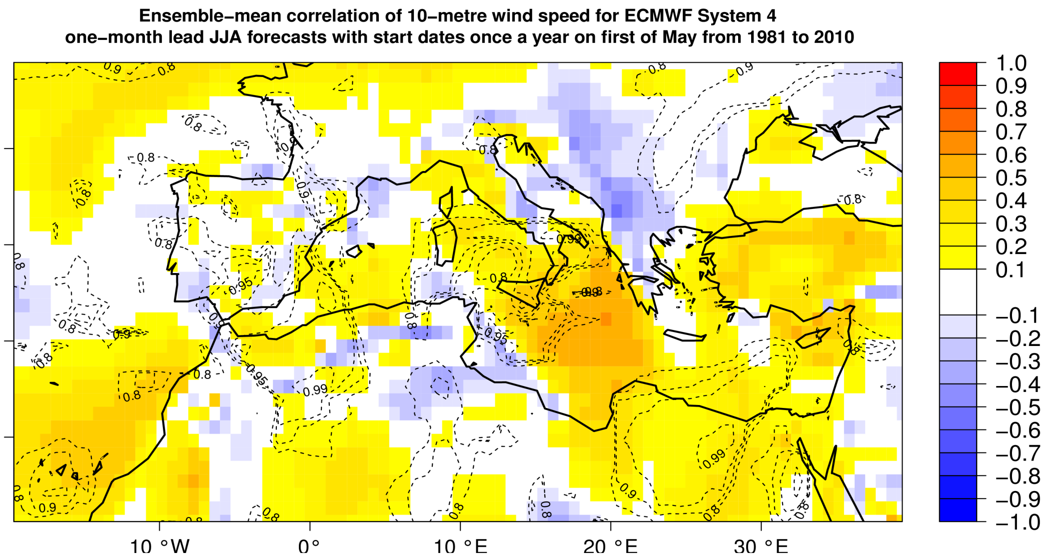






JJA 2010 10-metre wind speed anomaly

- Observation-based reanalysis
- Ensemble-mean forecast started in May
- Probability forecast started in May



JJA 10-metre wind speed anomaly verfification (1991-2010) for May started forecasts

Anomaly correlation skill with (1-p) in contours

Ithaca

IC3 Linux cluster 384 cores

Sun Microsystems X6270

Marenostrum

10240 cores,BladeCenter JS21,63 TeraFlop/s

Lindgren

36384 cores, Cray XE6, 305 TeraFlop/s

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